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REPORT NO. 91-16

MIL-STD-398 TEST OF
PROTOTYPE EXPLOSIVE
CONTAINMENT DEVICE (ECD)
FOR INITIATING EXPLOSIVES
UTILIZED IN DETONATOR
PRODUCTION

Prepared for:
Lone Star Army Ammunition Plant
ATTN: SMCLS-SF
Texarkana, TX 75501-9101

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SAVANNA, ILLINOIS 61074-9639

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U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NUMBER 91-16

MIL-STD-398 TEST OF PROTOTYPE EXPLOSIVE CONTAINMENT DEVICE (ECD)
FOR INITIATING EXPLOSIVES IN DETONATOR PRODUCTION

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by Lone Star Army Ammunition Plant (LSAAP), Texarkana, TX to provide MIL-STD-398, Military Standard Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, instrumentation services for measuring blast overpressure and thermal flux of the prototype Explosive Containment Device (ECD) when 1.25 ounces of lead azide is functioned.

B. AUTHORITY. This test was conducted in accordance with mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL 61299-6000. Reference is made to Change 4, 4 October 1974, to AR 740-1, 23 April 1971, Storage and Supply operations; AMCCOMR 10-17, 13 January 1986, Mission and Major Functions of U.S. Army Defense Ammunition Center and School.

C. OBJECTIVE. The objective of this test is to determine if the prototype ECD, Drawing Number EC-11835, meets the requirements of MIL-STD-398, Military Standard Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance; Methods 101, Blast Overpressure; 201, Fragment Retention; and 301, Heat Flux Measurement.

D. CONCLUSIONS:

1. Blast overpressure at the operator's position was 6.3 psi for a charge weight of 1.25 ounces of lead azide. The recorded pressure was incident. The recorded pressure was greater than the 2.3 psi limit.
2. The prototype ECD did not produce any shrapnel.
3. Thermal flux radiation recorded at the operator's position was less than 0.10 Btu/sq. ft.-sec.
4. Blast overpressure measurement indicated that the PECD, Drawing Number EC-11835, did not meet the requirements of MIL-STD-398, Military Standard Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance, in terms of blast overpressure.

PART 2

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PART 3

TEST PROCEDURES

DETAILED REQUIREMENTS

100 Class - Blast Attenuation Tests

200 Class - Fragmentation Tests

300 Class - Thermal Effects Attenuation Tests

CLASS-100 BLAST ATTENUATION TESTS

METHOD 101 BLAST OVERPRESSURE MEASUREMENT

A. PURPOSE:

1. Measurement of blast overpressure is conducted to ensure that personnel are not exposed to peak positive incident overpressure greater than 2.3 psi when the operational shield is subjected to a maximum credible incident (MCI).

2. An acceptable alternative to measuring peak positive incident overpressure is to measure peak positive normal reflected overpressure. Personnel shall not be exposed to a maximum positive normal reflected overpressure greater than 5.0 psi when the operational shield is subjected to an MCI.

B. **DESCRIPTION OF TEST.** An MCI is created with the operational shield. Blast pressure gages are used to measure blast overpressure.

C. **CRITERIA FOR PASSING TEST.** The operational shield shall be considered adequate if it can be determined from a pressure-distance plot of the data that personnel will not be exposed to a peak positive incident overpressure above 2.3 psi or a peak positive normal reflected overpressure above 5.0 psi.

D. **INSTRUMENTATION.** Blast Pressure Gages and Electronic Recording System. Based on the equivalent test charge, weight of explosives, and anticipated peak overpressure, the instrumentation system shall have the necessary response time and bandwidth to acquire data. Instrumentation shall be calibrated in accordance with current procedures of TB 43-180, Calibration Requirements for the Maintenance of Army Materiel.

E. TEST PROCEDURES:

1. When the shield is tested in a simulated operational bay environment, overpressure readings shall be taken at the following locations:

(a) At the center of probable head locations of each operator. For standing locations, the gages shall be positioned 65 inches above the floor; for sitting locations, it shall be 31.5 inches above the seat.

(b) At representative positions where transient personnel may be located.

2. When testing is conducted in open air, position blast pressure gages around the shield in two or three concentric circles at distances where it is expected that overpressures of interest will be found. Stagger the gages so shock waves reaching the outer circles are not distorted by gages in the inner circle. The gages shall be placed at a height of 65 inches.

3. All instrumentation shall be within calibration at time of test.

4. If the shield is designed for use with more than one model or type of ammunition, select the item that would produce the maximum overpressure.

5. Apply an overload equal to 25 percent or more of the filler weight of the ammunition selected for the test, unless otherwise directed in an approved test plan.

6. All major explosive components should be fused separately to ensure simultaneous detonation or deflagration in order to simulate the MCI, unless otherwise directed in an approved test plan.

7. Function explosives and record overpressure readings.

8. Prepare pressure-distance plots from overpressure recordings.

CLASS - 200 FRAGMENT RETENTION TESTS

METHOD 201 FRAGMENT RETENTION TEST

A. PURPOSE. Fragment testing is conducted to verify that a prototype operational shield will:

1. Contain all fragmentation or direct fragmentation away from areas requiring protection.
2. Prevent generation of secondary fragmentation within areas requiring protection.
3. Prevent movement, overturning, or structural deflections which could result in personal injury.

B. DESCRIPTION OF TEST. An MCI is created to test the operational shield.

C. CRITERIA FOR PASSING TEST:

1. Contain all fragmentation or direct fragmentation away from areas requiring protection.
2. Prevent generation of secondary fragmentation within areas requiring protection.
3. Prevent movement, overturning, or structural deflections which could result in personal injury.

D. TEST EQUIPMENT. Still picture camera equipment.

E. TEST PROCEDURES:

1. Fragment Retention Test.

(a) If the shield is designed for use with more than one mode or type of ammunition, select that item which will have the greatest potential fragmentation or shape charge effect.

Equipment, or reasonable simulation thereof, which shall perform the intended function on the ammunition, shall be positioned to generate secondary fragments.

(b) Apply an overload equal to 25 percent or more of the filler weight of the ammunition selected for the test, unless otherwise directed in an approved test plan.

(c) All major explosive components should be fuzed separately to ensure simultaneous detonation or deflagration in order to simulate the MCI, unless otherwise directed in the approved test plan.

(d) Function explosives.

2. Post-Test Procedures:

(a) Examine the interior and exterior for evidence of fragments. Photograph the shield to document the results.

(b) Examine the shield for movement, overturning, or structural deflections which could result in personal injury.

(c) Shields designed for intentional detonation shall be examined for damage and an estimate made as to the ability of the shield to remain operational as specified in the design criteria.

CLASS - 300 THERMAL EFFECTS MEASUREMENT

METHOD 301 HEAT FLUX MEASUREMENT

A. PURPOSE. Heat flux measurement is a condition of measure that personnel are not exposed to a maximum radiant heat flux determined in the equation given in criteria for passing test of this standard.

B. DESCRIPTION OF TEST. An MCI is created. Heat flux transducers are used to measure radiant heat flux.

C. CRITERIA FOR PASSING TEST. The operational shield shall be considered acceptable if it can be determined from heat flux-distance and heat flux-time plots to the test data that personnel will not be exposed to a radiant heat flux rating exceeding the formula:

$F = 1.0 / [(0.62t)^{0.7423}]$ cal/cm²-sec, where F is the thermal flux, T is the time in seconds.

D. INSTRUMENTATION. Heat Flux Transducers and Electronic Recording System. Based on the thermal flux expected at the location of the transducers, the instrumentation system shall have the necessary response time and bandwidth to acquire data. Instrumentation shall be calibrated in accordance with current procedures of TB 43-180, Calibration Requirements for the Maintenance of Army Materiel.

E. TEST PROCEDURES:

1. When the shield is tested in a simulated operational bay environment, heat flux readings shall be taken at the following locations:

(a) At the center of probable head locations of each operator. For standing locations the transducers shall be positioned 65 inches above the floor; for sitting locations it shall be 31.5 inches above the seat.

(b) At representative positions where transient personnel may be located.

2. In a free field test, flux values at various distances from the point of detonation can be estimated by the relationship: $O_1 \times d_1^2 = O_2 \times d_2^2$, where o =heat flux in Btu/in²-sec, and d =distance from point of detonation.

3. All instrumentation shall be within calibration at time of test.

4. If the shield is designed for use with more than one model or type of ammunition, select the item for the greatest heat flux.

5. Apply an overload equal to 25 percent or more of the filler weight of ammunition selected for the test, unless otherwise directed in an approved test plan.

6. All major explosive components should be fuzed separately to ensure simultaneous detonation or deflagration in order to simulate the MCI, unless otherwise directed in an approved test plan.

7. Function explosives and record radiant flux readings.

8. Prepare heat flux-distance and heat flux-time plots from radiant flux recordings.

PART 4

LONE STAR ARMY AMMUNITION PLANT

TEST PROCEDURE

PRELIMINARY

EM-8500/QAT

MAY 29, 1991

TECHNICAL PROGRAM NUMBER LS-326

SUBJECT: TESTING OF PROTOTYPE EXPLOSIVE CONTAINMENT DEVICE FOR INITIATING EXPLOSIVES UTILIZED IN DETONATOR PRODUCTION, DRAWING NUMBER EC-11035.

PURPOSE: TO DETERMINE IF THE PROTOTYPE EXPLOSIVE CONTAINMENT DEVICE (ECD) WILL ADEQUATELY CONTAIN THE EXPLOSION OF 1.25 OUNCES OF LEAD AZIDE AND COMPLY WITH REQUIREMENTS OF MIL STD 398. THE 1.25 OUNCES REPRESENTS THE MAXIMUM AMOUNT OF EXPLOSIVES TO BE TRANSPORTED IN THE DEVICE PLUS A 25% SAFETY FACTOR.

DISCUSSION: THE PROTOTYPE ECD WILL ULTIMATELY BE USED TO TRANSPORT INITIATING EXPLOSIVES FROM FRONT LINE STORAGE BARRICADES TO DETONATOR PRODUCTION EQUIPMENT. THIS COULD INCLUDE NOT ONLY AUTOMATIC DETONATOR MACHINES, BUT HANDLINES AS WELL. THE DEVICE WILL FURTHER REDUCE PERSONNEL EXPOSURE TO DRY INITIATING EXPLOSIVES. ACTUAL IN USE CONDITIONS WILL BE DUPLICATED WITH THE USE OF SPECIAL PURPOSE LEAD AZIDE AND THE IGNITION SOURCE WILL BE FROM TWO ELECTRIC MATCHES WIRED IN SERIES. THE LEAD AZIDE SHOULD PROVIDE MORE ACCURATE DATA IN DETERMINING PASS OR FAIL CRITERIA OF MIL STD 398. THE AZIDE WILL BE TRANSPORTED FROM AREA P TO XX TEST AREA SUBMERGED IN ALCOHOL VIA SPECIAL PANEL WITH SECURITY GUARD ESCORT. A STANDARD POWDER RECEPTACLE UTILIZED FOR BOTH NOL 130 AND LEAD AZIDE DETONATOR PRODUCTION WILL BE MODIFIED WITH FOUR 1/8 INCH HOLES IN THE BOTTOM. FILTER PAPER WILL THEN BE FITTED INTO THE VESSEL TO CONTAIN THE AZIDE YET ALLOW EXCESS ALCOHOL TO DRAIN OFF WHEN DESIRED. THE CONTAINER WILL THEN BE PLACED INTO A STANDARD CAR TRACK CARRIER IN THE COLLECTION BAY OF P-76. THE CAR WILL BE DISPATCHED TO A DESIGNATED AZIDE PRODUCTION DRYING BARRICADE WHERE THE POWDER DISPENSE LOAD CELL HAS BEEN CALIBRATED TO FILL THE UNIT WITH 1.25 OUNCES OF LEAD AZIDE. ONCE FILLED, THE CAR WILL BE DIRECTED BACK TO THE COLLECTION BAY AND THE CONTAINER WITH THE AZIDE WILL BE REMOVED AND SUBMERGED IN ALCOHOL IN A CONDUCTIVE CONTAINER WITH LID. IT WILL BE TRANSPORTED BY POWDER BUGGY TO P77 AND PLACED ON A DRYING TABLE FOR OVERNIGHT STORAGE. THE FOLLOWING DAY, WHEN THE ACTUAL TEST WILL TAKE PLACE, A SPECIAL PANEL, WITH SECURITY GUARD ESCORT, WILL TRANSPORT THE MATERIAL TO XX TEST AREA AT A SPEED NO GREATER THAN 25 MILES PER HOUR. THE AZIDE WILL BE SECURED BY PLACING THE STABILIZATION WILL BE OFFERED WITH DRESSING FILLED DRY SACKS PLACED AROUND THE VESSEL CONTAINING THE EXPLOSIVES. THE SECURITY ESCORT WILL REMAIN WITH THE EXPLOSIVE PANEL UNTIL IT CLEARS THE

GUARD GATE AT XX TEST AREA. ONCE THE AZIDE ARRIVES AT THE SITE, IT WILL BE UTILIZED IN THE TEST. STILL PHOTOGRAPHS, AND AFTER, AS WELL AS FASTEX FILM, WILL DOCUMENT THE EVENT. PROVIDE EVIDENCE OF FRAGMENT RETENTION. THERMAL FLUX AND OVERPRESSURE DATA WILL BE GATHERED BY USADACS PERSONNEL EQUIPMENT. SENSORS AND TRANSDUCERS WILL BE POSITIONED AROUND ECD TO DUPLICATE POTENTIAL LOAD BAY PERSONNEL LOCATIONS DURING ACTUAL PRODUCTION CONDITIONS. ONCE AGAIN, THE DEVICE IS DESIGNED TO INTERFACE WITH WALL BARRICADES AND DETONATOR PRODUCTION.

SHOULD OCCUR WHEN THE SPHERE IS BEING TRANSPORTED ACROSS THE BAY. WITH THIS IN MIND, THE TEST WILL BE CONDUCTED WITH THE DOOR IN THE CLOSED POSITION AS IF IT WERE IN ACTUAL TRANSPORT.

PROCEDURE: THE ECD WILL BE POSITIONED FOR TESTING IN XX 76 TEST AREA. IT WILL HAVE BEEN PREVIOUSLY MODIFIED WITH A SMALL, APPROXIMATELY 1/8 INCH HOLE, AND FITTED WITH A SHORT SECTION OF TWISTED FIELD LINE. RTV WILL BE APPLIED AT THE HOLE AREA, BOTH INSIDE AND OUT, TO SEAL THE VESSEL AS IT WOULD BE IN USE. ALL TRANSDUCERS, SENSORS, AND CAMERAS WILL NOW BE POSITIONED AND BEFORE TEST STILL PHOTOGRAPHS WILL BE MADE. THE TEST SUPERVISOR WILL DIRECT ALL PERSONNEL TO EITHER THE XX ADMINISTRATION BUILDING OR THE DETONATION BUNKER. ONLY THE TECHNICAL SPECIALIST WILL REMAIN WITH THE TEST SUPERVISOR FOR FURTHER PREPARATION OF THE DEVICE. TWO ELECTRIC MATCHES WILL BE FITTED INTO A SPECIAL STOPPER THAT WILL SIT IN THE TOP OF THE RECEPTACLE CONTAINING THE AZIDE. THIS STOPPER WILL HAVE DRYING VENTS TO ASSIST IN THE EVAPORATION OF THE ALCOHOL WHEN DESIRED. THE FIELD LINES WILL BE SHUNTED AT THE CONNECTOR BOX AND CONNECTED TO THE SHORT FIELD LINE FITTED TO THE ECD AND CHECKED FOR CONTINUITY AND EXTRANEOUS ELECTRICITY. IF THE CIRCUIT IS COMPLETE AND NO EXTRANEOUS ELECTRICITY IS DETECTED, THE LEAD WIRES AND FIELD LINE WILL BE CONNECTED. THE AZIDE WILL THEN BE REMOVED FROM THE CONDUCTIVE CONTAINER AND EXCESS ALCOHOL WILL BE ALLOWED TO DRAIN FROM THE FOUR PORTS BENEATH THE RECEPTACLE. ONCE THE ALCOHOL DRAINS TO THE BOTTOM OF THE RECEPTACLE, THE AZIDE WILL BE SEATED ON THE PEDESTAL INSIDE THE ECD. THE DOOR WILL REMAIN IN THE OPEN POSITION FOR ONE HOUR. THE TEST SUPERVISOR AND TECHNICAL SPECIALIST WILL THEN RETIRE TO THE XX-ADMINISTRATION BUILDING. AT THE END OF THIS WAITING PERIOD, THE TEST SUPERVISOR AND TECHNICAL SPECIALIST WILL RETURN TO THE ECD AND CLOSE THE OUTER DOOR. NO OTHER PERSONNEL WILL BE ALLOWED TO APPROACH THE DEVICE TO BE TESTED. THE TEST SUPERVISOR WILL ONCE AGAIN DIRECT ALL PERSONNEL TO ASSIGNED LOCATIONS. THIS WILL INCLUDE EITHER THE XX-ADMINISTRATION BUILDING OR THE DETONATION BUNKER. USADACS PERSONNEL AND DZI PHOTO TECHNICIANS WILL BE ALLOWED INSIDE THE DETONATION BUNKER WITH THE TEST SUPERVISOR TO OPERATE RECORDING EQUIPMENT.

THE CIRCUIT WILL BE CHECKED AT THE CONNECTOR BOX. IF NO DEFICIENCIES EXIST IN THE CIRCUIT, THE TEST SUPERVISOR WILL ASCERTAIN THAT ALL PERSONS ARE IN THEIR PROPER LOCATIONS. COMMUNICATIONS BETWEEN THE TEST BUNKER AND THE ADMINISTRATION BUILDING WILL BE MAINTAINED VIA TELEPHONE. THE BLASTING MACHINE WILL THEN BE

INTRODUCED TO THE CIRCUIT AND ACTIVATED.

SAFETY REQUIREMENTS: ALL ELECTRICAL CONNECTIONS WILL BE TAPED TO ENSURE ADEQUATE INSULATION.

THE CIRCUIT CONNECTOR BOX AND THE BLASTING MACHINE WILL BE LOCKED AT ALL TIMES EXCEPT WHEN FIRING. THE KEY WILL BE IN THE POSSESSION OF THE TEST SUPERVISOR AT ALL TIMES.

PERSONNEL LIMITS: ONLY THE TEST SUPERVISOR AND THE TECHNICAL SPECIALIST WILL BE ALLOWED IN THE VICINITY OF THE ECD WHEN EXPLOSIVES ARE BEING INTRODUCED OR ELECTRICAL CONNECTIONS ARE BEING MADE AT THE DEVICE. THE TECHNICIANS WILL BE LOCATED AT A SAFE DISTANCE FROM THE TEST SITE AND IN A PROTECTED ENVIRONMENT DURING THE ACTUAL DETONATION OF THE EXPLOSIVES. ALL OTHER PERSONNEL WILL BE LOCATED AT THE XX ADMINISTRATION BUILDING DURING THE TEST AND HANDLING OF THE AZIDE.

NOTE: DAY AND ZIMMERMANN AND ACO SAFETY OFFICES WILL BE NOTIFIED PRIOR TO THE TEST.

STANDING ORDER #63 WILL BE FOLLOWED IN EVENT OF ANY UNUSUAL OCCURRENCE.

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DATE TO TEST

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PART 5

TEST RESULTS

A. Blast Overpressure. Method 101. At operator's position, 1.25 ounces of lead azide- 6.31 psi peak incident pressure.

B. Fragment Retention Test. Method 201. No fragmentation was produced.

C. Heat Flux Measurements. Method 301. 1.25 ounces of lead azide- less than 0.1 Btu/sq. ft.-sec.

PART 6

PHOTOGRAPHS



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
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Photo No. EVT-91-16-02. This photo shows the prototype ECD positioned on a stand for function testing with the loading port closed. In normal operation the prototype ECD is transported on an overhead conveyor system. One transducer stand is positioned in front of the loading door, and the other test stand is at a possible transient personnel position. Both stands have blast overpressure and thermal flux transducers.



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<p>Photo No. EVT-91-16-03. This photo is a closeup illustrating the standoff distance between the blast overpressure and thermal flux transducers in relation to the prototype ECD. The prototype ECD was loaded with 1.25 ounces of lead azide and detonated to verify the shield integrity.</p>
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<p>Photo No. EVT-91-16-05. This photo shows the prototype ECD after detonating 1.25 ounces of lead azide. The device did not contain the detonation. Note, the deformed loading door and debris in front of the enclosure. Also note, the black line on the base. The black line was produced by the detonation and leaks at the hemisphere joint. The blast overpressure gage is at the right.</p>
